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OUR IGNORANCE CONCERNING INSECTS

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That, my friends, completes the serious part of what I came all the way from New York to say. Our ignorance concerning insects does not depress me because I feel certain that we shall learn. The insect menace does not frighten me because I believe that we can overcome it if we stop our calamity howling and get down to constructive fundamental work. In what follows I invite you to join with me in some of the excursions of a museum man who has had the curious Museum experience of having had charge for more than twenty years of a large taxonomic collection without ever describing a new species or changing the name of an old one.

While in Panama getting an exhibit of leaf-cutting ants I was astounded by the regularity with which they started and stopped their daily activities.[4] I was also pleased with the hours they kept, for they did not start until after my usual breakfast time and they stopped in time to allow me to take a shower before my evening meal. I had a watch to regulate my activities. They had none. I am supposed to have brains enough to be able to form habits. They have nothing but a string of ganglia and are supposed to be ruled by instinct.

To be sure, if you ask what instinct is you are apt to be told that it is an inherited habit and you may wonder how a creature can inherit habits without having habits to inherit. It is all very confusing and confusing things are interesting. So, one thing led to another, including my getting up before daylight every morning for a month to work out the curve of light-intensity with relation to sunrise and to record the exact time at which a wren sang its first song.[5] It is the old question as to whether roosters crow at dawn because of the increasing light or because it is time to crow. The most that I got out of attending those sunrise song services of the wren was a conviction that the bird was a combination of an organic alarm clock and a photometer. Its alarm clock was set for 5:58 A.M. but under certain conditions of light it went off as early as 5:50 and under other conditions as late as 6:04 A.M. Even so, an error of less than ten minutes one way or the other is not so bad for an organic clock, whether that clock be run by habit or by instinct or by something which is both or neither.

We are all familiar with the fact that some insects are diurnal; others are nocturnal; but I had an urge to get more detailed information concerning their daily cycles of activities and so I started a program of observations every two hours, day and night, with a mechanical alarm clock to waken me if I was sleeping. This program stopped early in the game when I awoke one

4. "Observations on Leaf-cutting Ants"; Lutz, Frank E.; 1929, American Museum Novitates No. 388.

5. "Light as a Factor in Controlling the Start of Daily Activity of a Wren and Stingless Bees"; Lutz, Frank E.; 1931; American Museum Novitates No. 468.

morning at six to find that I had not only turned off the alarm at two without getting up but that I had tucked the clock under me and had been sleeping on it. Furthermore, I wanted even more frequent observations than every two hours. Under such circumstances there was nothing to do but to make a machine.

I was using crickets and such things as subjects. Each cricket had its own little cage—two cages, in fact, connected by a narrow runway. In this runway there was a delicately counterpoised treadle. When a cricket wanted to be active it ran along the runway but its weight pushed down the treadle enough to complete an electric circuit in an electro magnet which pulled aside a pen that would otherwise have been tracing a straight line on a paper that was going through the machine at a known and constant speed.

There was no privacy left for the poor cricket but the device was great for a man who had at the same time curiosity and a desire for sleep. With a battery of twelve of these pens I have obtained automatic records of more than 10,000 insect-hours of activity. It would have required a staff or more than eight human assistants to have done as much in so short a time.

I wish that I could show you the graphs giving the curves of activity under different conditions of the normal day-night cycle, constant darkness, and reversed illumination but they were finished too late to have slides made from them and, furthermore, the work is being continued. So far as it has gone, it seems to show that these insects are creatures of habit, habits which can be changed but habits which persist after the conditions which changed them have been removed. In other words they can learn and remember; just as though they have brains.

Several summers ago I found myself spending some weeks in Maine. It was cold and foggy and wet. Not at all the kind of climate I like. However, one must make the best of circumstances and, since everything was cold and wet at any rate, I turned my attention to aquatic insects.[6]

In the ponds and streams were many case-bearing larvae of caddis-flies. An interesting thing about these cases is that each kind of larva has a characteristic choice of material and a definite style of architecture. The architecture, taking the group as a whole, is, like the materials used, most diverse, ranging from mere agglomerations of almost anything to a spiral case made of such fine grains of sand so neatly and regularly fitted together that it was originally described as the shell of a snail new to science. But, whatever the style of architecture or the choice of material, it is usually characteristic of a given species, sometimes even of a genus or family.

There is a correlation between the kind of a case which a species makes and the swiftness of the water in which it lives. Thus, the species which makes a "log cabin" case of small sticks placed crosswise lives in relatively still water while one that fashions a "masonry mosaic" of pebbles lives in streams. This is usually regarded as a wonderful adaption of behavior *to* environment, but, perhaps, since we do not know whether it was environment or behavior which changed it would be better to say that it is an adaptation *between* behavior and environment. Certainly a larva that made a log-cabin case in a stream would soon be washed down to still water. It is not quite so clear why species that

6. "Caddis-fly Larvae as Masons and Builders"; Lutz, Frank E.; 1930; Natural History, Vol. XXX.

make masonry cases should not live in still water and, in fact, they sometimes do.

Since the caddis flies are a relatively old group, being well represented at least as early as the Oligocene, and since certain types of larval cases are characteristic of genera or even of families based entirely on anatomical characters of adult insects, it is quite probable that a species which builds a given kind of case now has built nothing but that kind of case for thousands or even millions of years. What would a caddis larva do if it could not get material like that to which it has been accustomed and, furthermore, could it live without a case as do other aquatic insect larvae?

The answer to the first of these questions has been partly known for some time. Ostwald, in particular, got larvae to build with a great variety of unusual substances. In trying to find the answer to the second of the questions, I encountered a difficulty which had probably brought failure to others who said nothing about their failures, but I did find a few facts which seem to have an interesting bearing on the first question.

For example, four log-cabin builders were dispossessed of their cases and put into an aquarium with nothing but water, a little alga for food, and sea-sand made up largely of fine pieces of broken shells and sea-urchin spines. By the next day one larva had made a nice case of shells and sea-urchin spines; one used some of these, but mostly alga; and two were still naked. The following day three had shell and spine cases, the alga that one had used having apparently been worn or eaten off, and one still had no case, but there were two partly made and then abandoned cases in the aquarium.

The material normally used by the larvae which build the log-cabin type of case consists of more or less cylindrical pieces of soft, partly decayed twigs or, in this Maine locality, of spruce needles which had fallen into the water. These are placed very definitely in a transverse position, with reference to the larva's body. When I put the sea-sand into the aquarium, I did not notice that it contained a small amount of sea-urchin spines. It was, therefore, a matter of considerable interest that the larvae sorted over the sand and picked up here and there for use such a large proportion of relatively rare objects which came nearest to being the shape of their normal material. That this was not because they could not use the flat pieces of broken shell is shown by the fact that they did use a few of such pieces and, in the case of one larva, it started with the exceedingly thin and flexible strands of alga, although it later changed to sea-urchin spines and some broken shell.

This seeming exercise of choice, a possible evidence of real mental preference, was further illustrated in another experiment in which dispossessed log-cabin builders were first put into an aquarium with nothing but water and Utricularia, a delicate plant bearing curious "bladders" or pockets which entrap microscopic organisms. Nearly all of the larvae rather quickly made cases out of pieces of the plant which they bit off.

In order to understand more fully subsequent development it should be remembered that such a larva constructs its case by making a narrow ring through which it puts its head and then it widens the ring by adding material to the front side until the ring has become a cylinder as long as, or longer than, the larva's body. New material may occasionally be added to the side of a

case but, when the case is too short or for some other reason is not satisfactory, matters are usually adjusted by adding to the front end. Possibly the fact that the cases made by log-cabin builders, when they were forced to use shells and spines, were longer than normal was due to the insects' dissatisfaction with the new cases and their attempt to make them better by continued construction.

Be that as it may, the log-cabin builders in their Utricularia cases did not live peacefully together. One would come up behind another and steal a bit of plant from the case of the second in order either to eat it or to add that already-cut piece to its own case instead of cutting another piece for itself. After allowing this shifting of material from the rear end of one case to the front end of another to go on for a day or two, I put sea sand into the aquarium. Each larva had at that time a reasonably good, although rather short Utricularia case. However, each began picking up sea-urchin spines and adding them to the front of its case, occasionally, as though by mistake, fastening one to the side. Eventually, because the *Utricularia* was either worn or eaten off, most larvae had complete cases of sea-urchin spines.

Possibly the scarcity of broken shell in these cases, as contrasted with those made by naked larvae which started with nothing but sea-sand and a little alga, is to be explained by the fact that these larvae already had fairly satisfactory cases and, so, made a more leisurely and careful selection of material. I quite realize the danger of such a suggestion with its implication that larvae of lowly creatures think. Possibly the preference shown for spines over broken shell may have a purely mechanical explanation in the shape of the tarsal claws with which the building material is handled, but I am at present unable to suggest a purely mechanical explanation for this preference being more completely manifested when the larvae already had cases.

Larvae that normally make a somewhat curved case of fine grains of sand were dispossessed and given only the coarser bits of broken shell that had been sifted from sea-sand. In view of what has already been said, it is not surprising that they made cases of this new material. This experiment is mentioned here to show by this slide how well they handled the larger blocks, doing almost, if not quite, as well as a specjes which normally uses relatively large pebbles, the sort of case that was referred to as "masonry mosaic."

A more surprising result came when larvae, dispossessed of their fine-sand cases, were given only spruce leaves and small sticks taken from log-cabin cases. Some with very little hesitation, others with more, made cases. They did not arrange the material transversely, as do the log-cabin builders, but more or less longitudinally, as do many other species of caddis larvae. There is no warrant for making much of the fact that this is a better arrangement of material for species which, like these sand-builders, live in relatively swift water, but we can say very definitely that what was probably the first attempt this species had ever made in constructing cases from such material resulted in a neat and apparently very satisfactory shelter of a type quite different from its previous experience but entirely normal for other species.

Masons such as the sand builders just discussed or those that use small pebbles never cut material for their cases; they merely pick up pieces of suitable size. Therefore, the following experiment seems worth noting. On Aug-

ust 2, I dispossessed three sand-builders and gave them both living Utricularia and material taken from log-cabin cases. The next day one had made a case of spruce leaves, one used these and some fine débris, and one used spruce leaves but also pieces of Utricularia which it had cut off from the living plant. By August 6 this third larva had added sticks on the front of its case and had lost most of the Utricularia from the rear, probably by theft. Five days later, when all three had stick cases, I dispossessed two of them and put them in a new equarium with only Utricularia in the water. In the same aquarium I put two fresh sand-builders: one which I had robbed of about half of its case, leaving it in the much-too-short other half, and one which I entirely dispossessed. I do not know how things fared by the next day, but on August 13 the three which were entirely dispossessed had good cases made of pieces of Utricularia which they had cut from the plant; the one with a too-short case had done nothing about it. Thus matters stood for several days, but later one larva disappeared—I am not sure which one or how. There was considerable fighting and stealing of material from each others cases until, when the experiment was stopped on August 26, one larva was naked (possibly the one which had had a piece of a sand case) and the cases of the other two consisted chiefly of the silken lining with small bits of Utricularia and débris still attached.

Apparently cases made of material which can be eaten—gingerbread houses, as it were—are not extremely satisfactory, except to the eater, but the experiment suggests the possibility that these larvae, although not endowed by training and probably not by instinct with the notion of using vegetable material for their cases, can not only use such material but can do the, to them, unprecedented thing of cutting the case-building material into usable lengths. So far as this experiment goes the last statement is suggested as merely a possibility, there being the other possibility that they cut off pieces from the Utricularia for food and then, having the pieces, used them for making a case. However, the next and, so far as these notes are concerned, last experiment to be presented, seems to make the suggestion more probable.

Larvae that make tile-like cases of relatively large pebbles, the "masonry mosaic" type, were dispossessed and given the usual variety of unusual material. They managed them all so well that I finally gave some freshly dispossessed ones only large decayed leaves. Certainly these soft flat objects, too large to be fastened to a case without cutting, were very different from small, hard, round stones which are not to be cut. A creature whose ancestors to remote generations had never used anything but pebbles might not be expected to "think of" ("respond by" in more technical language) using decayed leaves or to be able to use them whether it really thought about the matter or not. All that I can say is that it did cut pieces out of the leaves and from them made the case.

One thing that should be mentioned again has been touched upon from time to time in these notes. Not all of the individuals of any of the species which were given these tests solved the problems. Quite probably most of those in any given experiment were brothers and sisters, or at least closely related, as they were collected together, but some would be immediately successful with the new material, others were slower or less successful; some tried for hours

and failed, leaving partly finished cases behind them, and some did not try. That the last fact was not due to lack of either silk or case-building urge was shown by their quickly making normal cases when given normal material. It almost looks like a variability of intelligence or ingenuity or something of the sort that many students suppose insects lack.

On the whole, without attempting to define either instinct or intelligence but selecting "behavior" as being the safer term, it seems clear that the case-building behavior of caddis-fly larvae is at least a rather flexible affair. Other more debatable points will occur to those familiar with comparative psychology and will perhaps be worked upon in those future laboratories where insects will be studied as "expressions of that Nature whose privileged offspring we claim to be", as living creatures to be understood and not as mere pests to be killed on sight. Nevertheless, the field is so vast and the problems are so large a part of the whole mystery of life that much of our ignorance concerning insects will still remain "when Earth's last picture is painted" and

"We shall rest, and, faith, we shall need it—lie
down for an aeon or two,
And the Master of All Good Workmen shall put
us to work anew.

. . . . . .

And only the Master shall praise us, and only
the Master shall blame;
And no one shall work for money, and no one
shall work for fame,
But each for the joy of working, and each,
in his separate star,
Shall draw the Thing as he sees It for the
God of Things as they are!"

FURTHER NOTES ON THE EPHEMEROPTERA OF THE NORTH SHORE OF THE GULF OF ST. LAWRENCE*

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In the "Canadian Entomologist" for March, 1930 (pp. 54-62) I commented on the Ephemeroptera collected in 1929 by W. J. Brown at various points along the north shore of the Gulf of St. Lawrence. Further studies by Mr. Brown in 1930 at Thunder River (June 12-28 and Aug. 15-29) and at Bradore Bay (July 4-16 and July 29-Aug. 12) have resulted in a number of additional records which I present in the following paper.

Baetinae

Blasturus cupidus Say. Common. Thunder River, June 13 (nymphs and adults); Bradore Bay, July 6.

Leptophlebia debilis Wlk. Common. Thunder River, Aug. 18-25. Nymphs corresponding to Ide's recent description (1930, Can. Ent. LXII, 210) were found in a small brook and bred through to the imago. Immature nymphs

*Contribution from the Division of Systematic Entomology, Entomological Branch, Dept. of Agric., Ottawa.

of apparently the same species were taken at Bradore Bay, Aug. 4.

Ephemerella aurivillii Bngtssn. Since recording this species under the name *aronii*, which at the time appeared to have priority, Bengtsson has shown in a recent paper (1930, Lunds Univ. Arssk. N. F. Avd. 2, XXVI (3) p. 3) that his name *aurivillii* was first established early in 1908 (K. Sven. Vet. Akad. Arsbok VI, p. 243) on a slight, but probably sufficient, indication; in consequence *aurivillii* Bngtssn. takes precedence over *aronii* Eaton (not Esb. Pet. as I recorded it). The species was found commonly as both nymph and adult at Thunder River, June 24-27, and some specimens were bred through; series were also taken at Bradore Bay, July 6 and 16.

Ephemerella funeralis McD. Nymphs were taken plentifully at Thunder River June 18-24; two were bred through and several females were bred from subimagos emerging from the stream, June 25-27.

Ephemerella verisimilis McD. Several specimens were reared from nymphs at Bradore Bay July 14, establishing the association made in my previous paper as correct.

Genus *Bactis* Leach

Four species of this genus were found in 1930 along the north shore of the Gulf of St. Lawrence and in every instance Mr. Brown was successful in associating nymph and adult. The following key will separate very easily the nymphs of these four species but it should be noted that the characters employed are not entirely specific but more in the nature of group-characters and cannot be used when working over nymphs from a region where several species of the one group may occur together.

1. Gills of segments 6 and 7 narrow, lanceolate ..... *pygmaeus* Hag.
   Gills of segments 6 and 7 oval, rounded 2
2. Caudal setae dark-banded beyond the middle ..... *cingulatus* McD.
   Caudal setae unbanded 3
3. Mid caudal seta about three-fifths the length of the outer ones; gill-tracheation very indistinct ..... *vagans* McD.
   Mid caudal seta about five-sixths the length of the outer ones; gill tracheation well-defined ..... *brunneicolor* McD.

Bactis brunneicolor McD. This species, not included on the previous list, was common at Bradore Bay from Aug. 2-10 and a few odd females were bred at Thunder River later in the month (Aug. 20-25), the main flight being then apparently over.

Bactis vagans McD. Occurred in numbers at Bradore Bay nearly a month earlier than the preceding species (July 5-8).

Bactis cingulatus McD. The earliest date of breeding was July 10 at Bradore and the species was evidently quite common by July 14; numbers of specimens were also taken early in August, these averaging somewhat smaller in size, especially in width of eye, than the earlier ones.

Bactis pygmaeus Hag.? A few females were bred at Thunder River, June 23 and several more females captured as subimagos. All nymphs taken were females and there is quite a possibility that the species will eventually prove distinct from the one occurring further west to which I have applied the name *pygmaeus*.

Centroptilum album McD. A long series was taken of adult males swarming at Bradore Bay on July 31 and Aug. 4. Three further nymphs were also secured which showed considerably more dorsal abdominal dark suffusion than given in my illustration (*op. cit.* Pl. IX, fig. 3), the pale color being confined to a double row of dorsal spots, most evident on the anterior segments. It might be noted that in the very closely allied species, *convexum* Ide (1930, Can. Ent. LXII, 222), the maxillary palp of the nymph (Pl. XVIII, fig. 4a) is represented as two-jointed, whereas my figure (fig. 3d) of the same organ in *album* shows the normal three-jointed condition. Having checked this up on the three additional nymphs and found that all showed a three-jointed palp I called the matter to Mr. Ide's attention who writes me that his *convexum* nymphs agree with *album* in palpal structure and that the line dividing off the apical joint was unfortunately omitted in his drawing.

Cloeon ingens McD. From a small pool in the tundra on an island near Bradore Bay a large collection of nymphs was obtained on Aug. 9. None were bred through but from subimagos found sitting on the surface of the water two female imagos were obtained. In general the nymph is rather pale in color with a broad dark band across the setae near their apices; the head, anterior to the antennae, is light ochre, the posterior portion being brown with a narrow pale ring around the eyes. The prothorax is brown with a pale median longitudinal line, adjacent to which in the middle section are two pale curved dashes; in the latero-anterior angle is a large pale subtriangular spot and behind this in the posterior section a still larger pale inverted U-mark. The mesothorax is brown with the pale median line of prothorax continued and with indistinct paler striping on the dorsum; the wing-pads are paler with the venation marked in dark and anterior to their base are several palish spots. The abdomen dorsally is rather variable in coloration but in general segments I-III and VI are brown whilst the others are pale with brown suffusion; on the dark segments the two pale subdorsal spots and dashes (as shown in my figure *op. cit.* Pl. VII, fig. 5) are distinct and show a tendency on segments II and III to enlarge into pale patches; on the pale segments there is no distinct maculation; venter pale. Legs pale with femora rather long and very finely spiculate; they are also tinged with light brown which in well-marked individuals tends to give the appearance of a pale longitudinal line along the outer side. I have already figured the details of the gills and mouth-parts; it might be noted that the seventh gill is usually somewhat more pointed than the illustration indicates.

Heptageniinae

Ameletus sp. Six rather immature nymphs were taken from a tributary of the Thunder River on June 16 but were not bred through; they differ considerably in dorsal maculation from the few nymphs of *ludens* which are available for study and show none of the central longitudinal dark banding which seems to be characteristic of this species. As it is quite possible, however, that they may belong to one of the Rocky Mt. species whose nymphs are still unknown, I do not care at the present time to describe the species as new.

Parameletus midas McD. This species was referred to in my previous paper as "*Sparrea* sp.". In 1930 (June 16-25) Mr. Brown was successful not only in obtaining a long series of adults from subimagos emerging from small pools

at Thunder River but also in actually breeding the species from the nymphs. A study of this material shows the species to be the one I described as *Siphlonuroides midas* (1923, Can. Ent. LV, 49); it, as well as the genotype, *croesus* McD., are apparently distinct from any of the European species formerly placed in the genus *Sparrea*.

Since the publication of my previous paper Bengtsson (1930, *op. cit.*, 13) has resurrected the prior generic name, *Parameletus* Bngtssn., which was very inadequately indicated in the Swedish Academy of Sciences' Year Book for 1908 in a report made by Bengtsson on his expedition; in his more comprehensive paper in 1909 (Lunds Univ. Arsskr. N. F. Afd. 2, V (4) 13) he disregards his former indication and seemingly in ignorance of the International Rules of Nomenclature proposes the new generic term, *Potameis*, over which *Sparrea* Esb. Pet. had a few months priority. The name *Parameletus* will apparently hold and the rather lengthy generic and specific synonymy is given by Bengtsson on page 15 of the above cited work. To this synonymy must now be added *Siphlonuroides* McD., which at the time I separated from *Siphlonurus* on the strength of the unforked median vein of the secondaries; this character is not mentioned by any of the European authors in the literature available to me at the moment but in view of the fact that other characters, both larval and adult, are similar to those given for *Parameletus* (*Sparrea*) I am sinking *Siphlonuroides* to this name. Larval details have already been presented in my previous paper.

Siphlonurus quebecensis Prov. A single male was bred, June 28 (adult July 1) from nymphs found in small pools at Thunder River; most of the nymphs were still immature at the time of Mr. Brown's departure from the village so it is probably that the main emergence of the species occurs later in July.

Siphlonurus barbarus McD. One male, bred at Thunder River June 28 (adult July 1). The nymphs were taken along with those of *quebecensis* and were unfortunately not recognized as distinct, nymphs and nymphal skins of both species being placed in the same vials. It is not surprising that this happened as the similarity between the nymphs is very great, so much so in fact that, while I have differentiated the material into two groups, I am unable to make exact associations as the nymphs are not mature and cannot be satisfactorily compared with mature ones of *quebecensis* from other sources. One point, however, is clear, viz.: that *barbarus* is a typical *Siphlonurus* in that the nymph possesses double gills only on the first two segments.

The above is the first Canadian record for the species and the first time I have encountered it since its description from a few specimens from the Catskill Mts., N. Y.

Arthroplea bipunctata McD. Several immature nymphs of an *Arthroplea* species which I presume to be *bipunctata* were taken at Thunder River, June 17 from a rapid tributary of the main river. In his recent paper (1930, *op. cit.*, 26) Bengtsson notes that *Cinygma bipunctata* McD. should probably be referred to *Arthroplea* and this reference is confirmed by Ide's discovery and description of the nymph of this species (1930, Can. Ent. LXII, 42). The 5-jointed nature of the male forceps is normal and not, as I thought at the time of description, an individual variation; five males before me, from various localities, all show this feature.

SOME ERYTHRONEURA (GRAPE LEAF HOPPERS) OF THE MACULATA GROUP. (HOMOPTERA CICADELLIDAE)

BY R. H. BEAMER,

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57. **Erythroneura forfex** n. sp.

General ground color semihyaline to white, marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Median white spot usually elongated and with very thin median orange line. Pronotum with median elongated spot often touching posterior margin, usual angular spot back of each eye. Scutellum with orange spot on tip, basal angles yellow. Coria with usual basal anchor-shaped spot with outer point heavy and shank very thin, also spot before tip. Coria with angular dash just before humeral angle, angular vitta arising on costa at anterior end of plaque and ending in enlarged portion parallel to claval suture near outer claval spot, and third angulate vitta arising at posterior end of plaque growing wider to end just before base of cell M_4. Cross-veins red. Tips of tegmen more or less dusky. Black spot in base of cell M_4 and another in posterior end of plaque. Venter stramineous.

Genitalia.. Pygofer hook double, two portions of unequal length, outer one shorter, both stout and almost straight curving slightly away and then back toward each other. Style with medium foot; heel medium; base slightly curved; almost no points, anterior one short, less than a right angle; posterior one short slightly more than a right angle. Oedagus of medium length, straight from any view, sides parallel, tip rounded, base forming sharp spine in lateral view.

Holotype; male, Polk Co., Ark., August 21, 1928, R. H. Beamer.

Paratypes; 1 male, Plummers' Id., Maryland, W. L. McAtee; 1 male, Walnut, North Carolina, August 20, 1930, R. H. Beamer, and one, same data as holotype.

The pygofer hook is characteristic of this species. Resembling somewhat that of *restricta* Beamer but differing in having parts shorter and heavier.

58. **Erythroneura lenta** n. sp.

General ground color semihyaline to yellowish white marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Pronotum with median elongate spot usually not reaching either margin and usual angular mark back of each eye. Scutellum with tip orange, basal angles yellow more or less margined with orange. Clavi with usual basal anchor-shaped spot and angular spot before tip. Coria with angular dash at base, irregular-sided, zigzag, vitta arising on costa at anterior end of plaque, more or less surrounding it and ending before base of cell M_4. Cross-veins partially orange. Tips of tegmen more or less dusky. Black spot in base of cell M_4 and smaller one in posterior end of plaque. Venter stramineous.

Genitalia. Pygofer hook single, slightly S-curved, rather long. Style with short foot; base almost straight; heel small; almost no points on toe, anterior one less than right angle projecting out; posterior point not projecting,

larger than right angle. Oedagus of medium length, in lateral view almost parallel-sided curved dorsally, tip rounded.

Holotype, male, Anderson Co., Kansas, Nov., 26, 1927, R. H. Beamer.

Paratypes; males from Kansas, Illinois, Louisiana and Maryland.

59. **Erythroneura unica** n. sp.

General ground color semihyaline to yellowish white marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Pronotum with rather small median angular-shaped spot not touching either margin, usual angular spot back of each eye. Clavi with usual basal anchor-shaped spot and angular spot before tip. Coria with spot on costa midway between plaque and base, irregular-sided more or less connected zigzag vitta arising on costa at anterior end of plaque surrounding it and ending before base of cell M_4. Cross-veins red. Tips of tegmen more or less dusky. Black spot in base of cell M_4 and in posterior end of plaque. Abdomen stramineous tinged with pink.

Genitalia. Pygofer hook single, slightly S-curved, parallel-sided to outer third where it enlarges and splits into two unequal branches, one shorter and narrower than the other. Style with medium foot; base almost straight; heel medium; almost no points, anterior one short, slightly less than right angle, projecting out; posterior point barely visible at all. Oedagus of medium length, almost straight, in lateral view nearly parallel-sided with round tip.

Holotype; male, Clayton Co., Iowa, April 19, 1930, R. H. Beamer.

Paratypes; following males, 3, same data; 1, Marshall, Ark., L. D. Anderson; 1, Washington, D. C.; 5, Maryland.

This species may be distinguished from all others with the split pygofer by the foot of the style having practically no points.

60. **Erythroneura manus** n. sp.

General ground color semihyaline to yellowish white marked with orange. Vertex with semblance of five white spots surrounded by broad orange bands, median white spot smaller and oval. Pronotum with heavy triangular median spot often touching posterior margin and usual angular spot back of each eye. Scutellum with spot on tip, basal angles yellow with orange on outer margin. Clavi with usual basal anchor-shaped spot and round blotch before tip. Coria with spot on costa before base, irregular-sided, zigzag, vitta arising on costa at anterior end of plaque, surrounding it and ending before base of cell M_4. Cross-veins reddish. Tips of tegmen more or less dusky. Base of cell M_4 and posterior end of costal plaque with black spot. Venter stramineous tinged with pink.

Genitalia. Pygofer hook single, with S-curve, enlarged into a hand-like tip. Style with medium foot; base almost straight; heel large; practically no points, anterior one about right angle; posterior one slightly projecting. Oedagus of medium length, in lateral view wide, curved dorsally near base, covered with ridges, tip rounded, base sharp pointed.

Holotype; male, Leavenworth Co., Kans., April 28, 1928, R. H. Beamer.

Paratypes; 2 males, same data; 1, Anderson Co., Kansas; 1, Clayton Co., Iowa; 1, Wabash Co., Ill.; 1, Walnut, North Carolina; 1, Plummer's Id., Md., W. L. McAtee; 1, Four Mile Run, Va., McAtee; 1, Dead Run Swamp, Va., McAtee.

61. **Erythroneura minor** n. sp.

General ground color semihyaline to yellowish white marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Pronotum with small median spot usually not reaching either margin, longer than wide with shallow U-shaped anterior portion, usual angular spot back of each eye. Scutellum with spot on tip, basal angles yellow with small dash of color on exterior margin. Clavi with basal anchor-shaped mark often broken in middle and rectangular spot before tip. Coria with spot on costa before base, angular dash at anterior end of plaque, rectangular spot opposite plaque, another at posterior end of plaque and angular one before base of cell M_4. Cross-veins red. Black spot in base of cell M_4 and in posterior end of plaque. Tips of tegmen almost hyaline. Venter stramineous tinged with pink. All markings delicate. Species small.

Genitalia. Pygofer hook single, slightly incurved, somewhat enlarged near tip where it ends in two points connected with even curve much as in *E. pyra* McA. Style with medium foot; base curved; heel pronounced; anterior point very short, about right angle; posterior point as long as foot, almost parallel sided, tip slightly curved out. Oedagus short, broad in ventral view, spines on tip, in lateral view straight, tip appears broken ending in a dorsally bent lip.

Holotype; male, Ames, Iowa, April 18, 1930, R. H. Beamer.

Paratypes, 4 males, same data; 1, Camp Perry, Ohio, W. L. McAtee.

62. **Erythroneura ballista** n. sp.

General ground color semihyaline to yellowish white marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands, median spot elongated to reach posterior border forming, with the median white spot between forks of Y-shaped pronotal spot, a rectangular white longitudinal band. Pronotum with median, narrow longitudinal mark arising on posterior margin, extending slightly more than half way across, where it divides into two narrow vitta, reaches anterior margin, extends along it to connect with usual angular spot back of each eye. This spot extends more than half way to posterior margin. Scutellum with spot on tip, basal angles yellow margined with orange. Clavi with usual anchor-shaped mark in base and spot before tip. Coria with spot on costa before base, an irregular sided, zigzag vitta surrounding plaque and ending before base of cell M_4. Cross-veins orange. Tips of tegmen dusky. Black spot in base of cell M_4 and posterior end of plaque. Venter stramineous tinged with pink.

Genitalia. Pygofer hook single, heavy at base, with strong S-curve, tapering to sharp point. Style with short foot; base curved; heel small; anterior point short about right angle; posterior point about as long as toe is wide, less than a right angle. Oedagus long, in lateral view, tapering from base to tip and bent dorsally into a semicircle.

Holotype; male, Lawrence Co., Ill., March 31, 1929, R H. Beamer.

Paratypes, 1 male, same data; 1, Polk Co., Ark., Aug. 21, 1928, R. H. Beamer; and 1, Plummers Id., Md., W. L. McAtee.

Characterized by the peculiar bend in the oedagus.

63. **Erythroneura penerostrata** n. sp.

General ground color semihyaline to white marked with orange. Vertex with semblance of five white spots surrounded with orange bands, median white spot oval. Pronotum with small median spot sometimes projected forward by very thin lines at anterior corners. Usual angular mark back of each eye very small. Scutellum with tip orange, basal angles yellow with thin orange mark on outer margin. Clavi with basal anchor-shaped mark not much more than a line, and small spot before tip. Coria with small dash on costa midway between plaque and base, another at anterior end of plaque, spot opposite middle of plaque, three more at posterior end and another one just before base of cell M_4. Cross-veins orange. Tips of tegmen slightly dusky. Small black spot in base of cell M_4, smaller one in posterior end of plaque. Venter stramineous.

Genitalia. Pygofer hook single, slightly longer than pygofer, widest at base, narrowing beyond middle, almost straight. Style with medium foot; base almost straight; heel medium; anterior point less than right angle, projecting out, about as long as toe is wide; posterior point longer, slightly narrower, forming slightly more than right angle with base of foot. Oedagus large, beak-shaped, thickened on ventral margin, in lateral view very broad, bent at almost right angles to base, ending in sharp lip-like tip.

Holotype; male, Marshall, Ark., March 22, 1931, L. D. Anderson.

Paratypes; 1 male, same data, and one from Bowie Co., Texas, R. H. Beamer.

64. **Erythroneura crinita** n. sp.

General ground color white marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Pronotum with rather narrow, longitudinal spot usually touching posterior margin and usual angular spot back of each eye. Scutellum with spot on tip, basal angles yellow with orange mark on outer margin. Clavi with usual anchor-shaped mark and spot before tip. Coria with orange dot on costa before base, irregular-sided more or less connected, zigzag vitta surrounding plaque and ending before base of cell M_4. Cross-veins orange. Tips of tegmen more or less dusky. Black spot in base of cell M_4 but none in posterior end of plaque. Venter stramineous; legs often pink.

Genitalia. Pygofer hook single, short, bent sharply out on outer third, surrounded with band of hairs in this region. Style with long foot; base almost straight; heel medium; anterior point short, sharp, projecting out; posterior point longer and narrower forming less than a right angle with base of foot. Oedagus of medium length, straight in ventral view with a pair of dark processes arising at base of shaft, projecting laterally from it, shaft in lateral view very wide and evenly curved ventrally.

Holotype; male, Marshall, Ark., March 22, 1931, J. O. Nottingham.

Paratypes; 10 males, same place, by Nottingham and Beamer; 1 male from Dead Rum Swamp, Va., W. L. McAtee.

This species is close to *E. andersoni* n. sp. as evidenced by both having a band of hair around pygofer hook. It may be separated from it by the very broad oedagus in lateral view.

65. **Erythroneura andersoni** n. sp.

General ground color white to yellowish white. Marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Pronotum with median V or heart-shaped spot usually not touching either margin. Usual angular spot back of each eye. Scutellum with orange tip, basal angles yellow outlined on two sides with orange. Clavi with basal anchor mark with points well defined, and spot before tip. Coria with small spot on costa midway between plaque and humeral angle, zigzag, irregular-sided, more or less connected vitta surrounding plaque and ending at or before cross-veins. Cross-veins more or less orange. Tips of tegmen slightly dusky. Small black spot in base of cell M_4, costal plaque usually without black spot. Venter stramineous more or less tinged with pink.

Genitalia. Pygofer hook short, almost straight, tapering evenly from both sides to tip, surrounded near middle with rather long hairs. Style with long foot; base straight; heel short and sharp; anterior point short, sharp, projecting out; posterior point shorter and sharper, projecting at about right angle to base of foot. Oedagus long almost straight from any view, tip bent dorsally, two processes arise near base and extend almost to tip, usually parallel with shaft.

Holotype; male, Marshall, Arkansas, March 22, 1931, L. D. Anderson.

Allotype; female, same data. Numerous paratypes of both sexes from Arkansas and Kansas.

66. **Erythroneura curta** n. sp.

General ground color semihyaline to yellowish white marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Pronotum with median triangular spot, longer than wide, usually not touching either margin, usual angular spot back of each eye. Scutellum with spot on tip, basal angles yellow with orange dash on outer margin. Clavi with usual orange anchor-shaped mark and spot before tip. Coria with small dash midway between plaque and humeral angle, an irregular margined dash at anterior end of plaque, spot at posterior end and triangular spot before base of cell M_4. Black spot in base of cell M_4 and smaller one in posterior end of plaque. Cross-veins more or less orange. Tips of tegmen slightly dusky. Venter stramineous.

Genitalia. Pygofer hook single, rather long and slender, somewhat curved in on outer third with slight thickening at tip. Style with medium foot; heel medium; base curved; anterior point very short about a right angle; posterior point about two-thirds length of foot, narrow, sides converging. Oedagus very short, about same length as posterior point, straight, tip rounded, sides parallel.

Holotype, male, Clayton Co., Iowa, April 19, 1930, R. H. Beamer.

Paratypes; numerous males from Iowa and Maryland.

67. **Erythroneura lata** n. sp.

General ground color semihyaline to milky-white marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Pronotum with median, narrow triangular spot and usual angular spot back of each eye. Scutellum with tip orange, basal angles yellow with orange dash on outer margin. Clavi with usual basal anchor-shaped mark and spot near tip. Coria with small dot on costa just before humeral angle, more or

less connected, irregular-margined vitta surrounding plaque, and irregular shaped spot before base of cell M_4. Cross-veins orange to red. Black spot in base of cell M_4, none in posterior end of plaque. Tips of tegmen more or less dusky. Venter stramineous. All markings noticeably narrow.

Genitalia. Pygofer hook single, almost straight, broadest on basal two-thirds, tapering to sharp point at tip. Style with medium foot; base curved; heel large; anterior point sharp, about right angle; posterior point about half as long as foot, very narrow, distinctly curved in. Oedagus short, in ventral view much broadened and concave at tip with irregular margin, in lateral view broad at base, curved dorsally on outer third, ending in sharp point on dorsal margin.

Holotype; male, Maryland.

Paratypes; males as follows: Dead Run Swamp, Va., W. L. McAtee, 1; Marshall, Ark., 3; Batesburg, South Carolina, 9 teneral specimens.

This species is close to *E. sancta* Beamer but may be distinguished from it by the different shape of the foot of the style. The posterior point of the latter being straight and as long as the foot.

68. **Erythroneura knighti** n. sp.

General ground color semihyaline to yellowish white marked with orange. Vertex with semblance of five white spots more or less surrounded with orange bands. Pronotum with median triangular spot not touching either margin, sometimes with arms at anterior corners, and usual angular spot back of each eye. Scutellum with spot on tip, basal angles yellow. Clavi with usual basal anchor-shaped spot, not as well defined as most species, and indication of a spot before tip. Coria with small spot midway between plaque and humeral angle, dash at anterior end of plaque, rectangular spot on disc opposite middle of plaque and a more or less connected row of spots from posterior end of plaque to base of cell M_4. Cross-veins orange on costal margin. Tips of tegmen more or less dusky. Small black spot in base of cell M_4, usual one in posterior end of plaque wanting. Venter stramineous.

Genitalia. Pygofer hook single, reaching to end of pygofer, tapering from base to tip, slightly S-curved. Style with medium but short foot; base curved; heel large; anterior point short, slightly less than right angle; posterior point narrow, longer than foot, sides almost parallel. Oedagus of medium length, almost straight, in lateral view broad, parallel-sided, tip flattened ventrally.

Holotype; male, *allotype;* female, *paratypes;* Ames, Iowa, April 18, 1930, R. H. Beamer.

This species is rather less than medium sized with the markings light and the basal mark on clavus tending to a longitudinal dash.

The oedagus with ventral corner appearing as if cut off separates it from those closely related.

69. **Erythroneura septima** Beamer

Erythroneura septima Beamer, R. H. Can. Ent., LIX, p. 30, Feb. 1927.

Allotype; male, Anderson Co., Kansas, Nov. 26, 1927, R. H. Beamer.

Genitalia. Pygofer hook single, with slight S-curve, about as long as pygofer. Style with medium foot; base straight; heel prominent; anterior point hardly as long as toe is wide, projects out; posterior point as long as foot, sides

almost parallel, forms slightly less than right angle with base of foot. Oedagus about as long as foot, almost cylindrical.

This species is quite close to *E. lunata* McA. but since this latter species does not have so definite a seven mark on tegmina and the pygofer hook curves in instead of being S-curved we will let it stand for the present.

70. Erythroneura pyra McA.

Erythroneura pyra McAtee, W. L. Proc. Biol. Soc. Wash., Vol. 37, p. 133, Dec. 29, 1924.

"Vertex, pronotum, and scutellum ivory colored without definite markings; tegmina milky white with the following scarlet markings; nearly all of basal third of clavus, a band near apex of clavus, and a broad vitta between claval suture and costal plaque. The common pattern of the disk of tegmina is a truncate triangular figure, almost straight across distal end (the base), and jagged on sides, in scarlet, enclosing a somewhat pear-shaped area of the ground color on middle of the clavi. In the type the vittae are orange in bases of clavi, but this may be due to fading. The costal plaque is chalky with a dark spot at posterior end, there is a dash of red on outer cross-vein at costa, and a dusky spot in base of fourth apical cell. Underparts pale yellowish.

Holotype: male, Berwick, Iowa, Sept. 28, 1895, C. W. M.

This species belongs in group 4 and suggests *E. hartii* in appearance; the pale saddle spot is quite different, however, both in shape and position."

A specimen of this species from Ill., determined as this species by McAtee was dissected and found to have the following genitalia:

Genitalia. Pygofer hook single, slightly longer than pygofer, gradually widens from near base to bifid tip, line between two points an even curve. Style with medium foot; base curved; heel large; anterior point about a right angle; posterior point as long as or longer than foot, almost parallel sided. Oedagus short, almost straight, covered with spines almost to tip.

Type, male, in the collection of the State College of Iowa, Ames, Iowa.

(to be continued)

THE BIOLOGY OF THREE NORTH AMERICAN SPECIES OF MESOVELIA (HEMIPTERA-MESOVELIIDAE)*,†.

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INTRODUCTION

The purpose of this paper is to present what is known at the present time concerning the life histories and habits of the Mesoveliidae, particularly those of three species of the genus *Mesovelia* Muls. found in North America. Studies on our most common species, *Mesovelia mulsanti bisignata* Uhler, were carried out in Michigan and Kansas, while biological notes on the other two species were taken in the region of Douglas Lake, Michigan, their only known habitat. Isolated rearings and life history studies of all three species were made at Lawrence, Kansas. Not only had the biology of these forms been practically untouched, but an earlier investigator's results led me to expect a high mor-

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*Contribution from the Biological Station of the University of Michigan.

†Submitted to the Department of Entomology and the faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the Degree of Master of Arts.

tality among the Mesovelia. It was with much determination as well as interest, therefore, that the writer observed and reared large numbers of these most interesting little bugs of the water.

The writer wishes to express his appreciation and gratitude to Dr. H. B. Hungerford, head of the Department of Entomology of the University of Kansas, for the opportunity of making this study as well as for his kindly help and criticism. The writer also wishes to acknowledge his indebtedness to Dr. Kathleen Doering for advice concerning the preparation of illustrations, and to all those fellow students whose associations and assistance have aided me in the completion of this paper.

HISTORICAL ACCOUNT AND SYSTEMATIC POSITION OF MESOVELIIDAE FAMILY

An excellent abbreviated history of the family Mesoveliidae is given by Horvath (9) in the preface of his *General Catalogue of the Hemiptera*, Fascicle 2, "Mesoveliidae". The preface, which is a part of the Introduction to his Monograph published in 1915, reads as follows in idiomatic English:

" 'The Mesoveliids constitute a small family of Hemiptera-Heteroptera whose representatives live on the surface of stagnant waters or in a quiet stream. However, a species of New Guinea, the type of a new genus Phrynovelia, has not been found on the water, but under fallen leaves.

"The first species described in 1852 by Mulsant and Rey, *Mesovelia furcata*, was ascribed by the authors to the Amphibicorises near the genera Velia Latr. and Microvelia Westw. Dohrn (1859) united the genus Mesovelia Muls. and Rey with the genus Hebrus Curt. in the family of the Hebrids. Fieber (1861), Sahlberg (1875) and Uhler (1894) placed it in the family of the Veliids. Jakowleff who described (1874) the genus Mesovelia under the name Fieberia as new, ascribed it to the Hebrids; G. C. Champion also followed his example later (1903). Since the Veliids, Hydrometrids and Gerrids, sometimes also the Hebrids, have been united as sub-families in one single family called first Hydrodromica, then Hydrometridae or Gerridae, the majority of authors have also placed the Mesoveliids in this family as a separate sub-family. But Puton (1879) justly pointed out that the genus Mesovelia will appear to have to constitute rather a separate family, on account of the numerous differences which it presents with the other Hydrometrids (Gerrids). Puton and the other Hemipterists forgot, however, that Douglass and Scott already established the family of the Mesoveliids in 1867. It is only in 1908 that A. Handlirsch cited, in his authoritative work on insect fossils, the Mesoveliids as a distinct family; it is only since then that they have been generally considered as a separate family.

"The systematic position of the family of Mesoveliids remained uncertain and doubtful for a rather long time. The general facial expression of these Insects and their habitat caused them to be placed in the Amphibicorises since the beginning, but their relations were not sufficiently elucidated and determined. Douglas and Scott (1867) united them with the Hebrids in the section of the Hebrina. Handlirsch (1908) represented them in his genealogical tree as receiving their origin from the branches of the Hydrometrids from which the Hebrids and the Aepophilids are perhaps also descendants. J. R. de la Torre-Bueno (1908) compared the Mesoveliids, because of a certain re-

semblance of the eggs, to the family of the Nabidids. My late friend O. M. Reuter who dedicated the last years of his laborious life with as much zeal as success to phylogenetic and systematic studies of the Heteroptera, considered the Mesoveliids first (1910) as a phalanx of the superfamily Gerroideae, but in one of his last works (1912) he compared them to the Hebrids, in uniting these two families in one phalanx of the superfamily of the Deduvioideae, neighbor of the phalanx Nabiformes.

"It seems to me, however, that Reuter in this case attributed too great an importance to the structure of the eggs, and that neither the Mesoveliids nor the Hebrids are in their right place in the superfamily of the Reduvioideae. In my opinion it is necessary to carry them back to the superfamily of the Gerroideae. In examining these two families more attentively, one is not able to disregard their relationships with the other three families of the Gerroideae. The presence of an orifice of the odoriferous gland on the metasternum, which is such a remarkable and exclusive character of adult Gerrids and Veliids, seems to me of the greatest importance in guiding us in the phylogeny of these Insects. The structure pretty nearly identical with the rostrum is also an indication of their affinity.

"The family of Mesoveliids is represented in all the zoogeographical regions of the globe and contains 2 genera and 14 species known at present."

REVIEW OF AMERICAN SPECIES OF GENUS MESOVELIA WITH KEY TO MESOVELIA OF EASTERN AMERICA

The first American species of the genus *Mesovelia* Muls. discovered was *Mesovelia mulsanti*, which was described in 1879 by F. B. White from the Hemiptera collected in the Amazons by Prof. J. W. Trail (21). Uhler, in 1884, described *Mesovelia bisignata* from specimens of the United States (19). In 1898, Champion (7) placed *Mesovelia bisignata* Uhl. as a synonym of *Mesovelia mulsanti* White. Recently, Jaczewski (15) has made several sub-species out of *Mesovelia mulsanti* White, because of differences in the shape of the gonapophyses, and because each of the sub-species seems to have a more restricted area of distribution of its own. Accordingly, the same writer proposes to call *Mesovelia mulsanti bisignata* Uhler the North American subspecies; it was heretofore called *Mesovelia bisignata* Uhl. or *Mesovelia mulsanti* White by most North American authors. In 1894, Uhler (20) described *Mesovelia amoena* from the Island of Grenada. Then in 1924, Hungerford described two new American species of *Mesovelia* Muls.; namely, *Mesovelia douglasensis* (12) and *Mesovelia cryptophila* (13), both descriptions of which were based upon specimens from Douglas Lake, Michigan. *Mesovelia bila*, the fifth American species of the genus *Mesovelia* Muls., was described by Jaczewski (14) in 1928 from the South Brazillian State of Parana.

A survey of the literature concerning the biology of the members of the family Mesoveliidae shows that such information is somewhat limited and scattered. The biology of *Mesovelia furcata* Muls. and Rey, a European species of the genus *Mesovelia* Muls., is apparently confined to the following accounts: Scott (18), Butler (5), Lundblad (16), Bollweg (21), Guide (8), Butler (6), and Poisson (17). Biological information on *Mesovelia mulsanti bisignata* Uhl. is restricted to studies made by Uhler (19), Bueno (3), Hungerford (10),

Hungerford (11), and Bueno (4). Hungerford (10) worked out the life history of this species, and gives an excellent account of it in his paper entitled "The Life History of *Mesovelia mulsanti* White". Except for some biological notes on *Mesovelia douglasensis* Hung. by Hungerford (12), nothing has been done on the biology of the remaining species of the genus *Mesovelia* Muls.

The species of Eastern North America have been separated by Blatchley (1) as follows:

" a. Larger, length 3.8-4 mm.; hind margin of front and middle femora with a row of spines; beak reaching base of hind coxae; first genital of male with tufts of black setae on lower side. *M. mulsanti.*

aa. Smaller, not over 2.8 mm.; hind margin of front and middle femora without spines; first genital of male without setae.

b. Beak reaching first ventral.

c. Head brown with a narrow median pale line; joint 1 of antennae not passing hind margin of eye; general color mottled brown, shining. *M. douglasensis.*

cc. Head grayish with two narrow parallel dark lines; joint 1 of antennae surpassing hind margin of eye; general color olive-green, thickly covered with a fine grayish bloom. *M. cryptophila.*

bb. Beak reaching between middle coxae; head yellow with two brown stripes. *M. amoena.*"

THE BIOLOGY OF MESOVELIA MULSANTI BISIGNATA UHLER

Habitat.—Mesovelia mulsanti bisignata Uhl., the largest of the three species of *Mesovelia* Muls. considered in this paper, lives upon the floating shoreward vegetation of the waters of ponds, marshes, bogs, and other such bodies. Uhler (19) found members of this species on the leaves of *Potamogeton;* Bueno (1) on duckweed, matted hydrodictyon, and other algae floating on the surface of ponds; Hungerford (11) about old logs projecting from the water, about clumps of smartweed at the water's edge, on rafts of filamentous algae, and on the leaves and stems of such plants as water shamrock, procumbent upon the surface; while the writer has found them on *Nymphaea* and amidst thick growths of *Chamaedaphne,* as well as on some of the above named plants. Both winged and wingless forms occur in this species, but the latter ones far outnumber the winged forms.

Hibernation.—This species is thought by most writers to overwinter as an adult, but conclusive evidence is lacking. The writer made numerous trips to Lake View, a large standing body of water about 6 miles northwest of Lawrence, Kansas, in order to watch this species during the fall and winter months. It was exceedingly dry during the fall months and the water of this lake receded about 20 feet a month, thus making observations difficult. In October, hundreds of apterous forms were present along the lake shore and also in the small inlets from the lake which contained an abundance of algae and larger aquatic plants. By the middle of the following month, however, their numbers had diminished; and the males and females were found in groups of from 10 to

30 under dead lily leaves which were partially hidden in the mud. Most of the bugs were found about two feet from the water's edge, and no doubt the cold weather caused them to be found lying flat against the leaf or on the mud. They were inactive and moved about only after being disturbed. A dead apterous male, found under a lily leaf on November 26, 1930, was the last specimen taken, the others disappearing mysteriously. I might say that the above observation was made after a series of hard freezes. Searches through several tubs-full of mud and debris which had been removed from the edge of the water and from a few feet back of the water margin, and which were examined in the laboratory, failed to reveal any hibernating adults.

Adults collected at Lake View in November were brought to the laboratory, where they soon became very active, fed voraciously, mated, and laid eggs within a few days. A housefly was tossed in a dish containing 20 adults, and within a few minutes all of them had their beaks in the fly. Some of the eggs laid by these adults hatched out in a couple of weeks, while others hatched intermittently throughout the months even up to May.

Some eggs of *Mesovelia mulsanti bisignata* Uhl. laid in pieces of cattail leaf during the middle of August in Michigan, were taken to Kansas, where they were placed in the laboratory and where a goodly number hatched out at intervals of about a week from that time on until the month of May. Another piece of cattail leaf containing eggs laid the same month was placed in refrigeration at 32°F. for about a month; i.e. from October 25 to November 25, and between the third and eighth of December fifteen eggs hatched out. Thus the eggs can withstand freezing temperature and might do so in their normal habitat.

On May 2, 1931, after the completion of the first draft of this paper, the writer decided to visit Lake View once more in an attempt to be present at the first appearance of hibernating adults. Much to his surprise, however, he found a large number of first instar nymphs, but no amount of searching revealed adults. These nymphs, then, would appear to come from over-wintering eggs and do not seem to be the progeny of over-wintering adults.

Mating.—Hungerford (11) gives the following account of mating in this species: "In mating the male mounts the female, clasps his fore legs around her mesothorax in front of her middle legs, rests his middle legs upon the water film or other supporting surface, and holds the hind legs poised in the air. The copulatory organ of the male is long and curves around the side of the tip of the female's body to come in contact with the genital opening. Contact lasts from a few seconds to one minute or longer. Upon withdrawal the copulatory organ is seen to be a slender white tube of astonishing length". Copulation may take place on the water or on vegetation, and a number of pairs were observed mating in the bottles in which they were collected. It has been noted that the male used the hind legs to advantage in keeping his equilibrium, and that mating is terminated by vigorous kicking on the part of the female.

Preoviposition.—The preoviposition period seems to lie between 2 and 6 days. Hungerford (10) states that "mating occurs and oviposition begins about the third day", while most of my records show the preoviposition period to be about six days in length.

Oviposition and fecundity.—Butler (5), in 1893, called attention to the fact that *Mesovelia furcata* Muls. and Rey mated several times and that the bodies of the females became greatly distended at the end of three weeks. Although the same writer failed to find out the method of oviposition, he noted that impregnation took place in the summer. *Mesovelia mulsanti bisignata* Uhl. protects its eggs by placing them in the tissues of certain plants by means of an ovipositor as is mentioned by Bueno and Hungerford (11). Hungerford (11) describes the method of oviposition as follows:

"The female frequently explores the stem with the tips of her beak and antennae if indifferent in the matter, but if eager to oviposit, she mounts the stem without delay, raises the abdomen slightly, unsheathes the ovipositor and turns its tip down to the surface of the stem. At times the surface is tested out at several points—again if the first point of contact is favorable, the tip is caused to quiver back and forth till it gains a footing, and then rocking the body slightly from side to side the entire drill is caused to rotate or twist back and forth on its axis, rapidly at times, or again more slowly as may suit the necessity of the work, until a hole is effected and the ovipositor is buried to its base. During the deeper drillings the longitudinal alternate thrusts of the drill parts are apparent. The first part of the operation at least involves much the same sort of motion as one employs in making a hole with a gimlet or awl. It takes but a moment in the spongy, water-soaked stem of a sedge to drive the instrument up to its base. Then, after a moment of apparent quiet, the ovipositor is lifted slightly and the egg is forced by a series of abdominal contractions down the ovipositor and into the cavity reamed out to receive it". He also points out that the male often remains on the back of the female as she is ovipositing, and that mating is attempted and often consummated between her labors.

In the laboratory, many females not only deposit eggs in plant tissue, but lay them on the surface of the plants and in the water. None of the eggs laid on the surface ever hatched. One female laid 104 eggs in about one and one-half months, but most of the females laid a smaller number of eggs and died within a month's time.

Incubation.—Hungerford (11) observed that the egg stage lasted from 7 to 9 days, and that the deep red eye spots are present 2 days before hatching. The writer found the above incubation period to be correct for some eggs—and doubtless this is the normal one—, but the period was much greater for most of the eggs kept under observation. For example, eggs laid in the laboratory during August and during the fall hatched out irregularly even until the following May.

Hatching.—Hatching has been observed by Hungerford (11), and he gives the following description: "At hatching the young nymphs, still enclosed in their embryonic membrane, work their way up through the little circular openings of the stem. This is a remarkable feat, considering the size of the nymph and the size of the hole, but is aided materially by the peculiar backward pointed pegs on the thin embryonic membrane. When well out of the stem, this membrane is cast and the nymph takes its place upon the water".

Behavior of the newly hatched.—The newly hatched, which are light in

color and have red eyes, are larger and more active than the other two species considered in this paper. They are so agile that it is often difficult to change the food and water in their containers without having them scamper up and out of the glass stender without warning. They are ready for a meal as soon as they straighten out the limbs and give them a thorough cleaning. Within a few hours, the little nymphs darken to amber and finally become green. When disturbed the nymphs draw the legs close to the body and remain motionless, thus becoming hard to detect from other particles in the water.

Number of instars.—There are five nyimphal instars as was noted by Hungerford (11). The duration of the several stadia is given in the Table of Rearings.

Molting.—Molting may take place upon floating material, on the sides of the stender near the water, or on the water itself. The process is not unlike that described for *Mesovelia douglasensis* Hung. Most of the little bugs are able to free themselves from their old skins in 2 or 3 minutes, but it takes about 10 minutes for them to straighten out their legs and walk away. The greatest mortality occurs in the first and fifth instars because of the nymphs' inability to molt. The skin is either found split at their death, or else their regular molting period is overdue in comparison with that of other rearings. Mortality is shown in the Table of Rearings for the third, fourth, and fifth instars.

Longevity.—Adults collected in the field in both Michigan and Kansas, and those obtained by rearing, indicate the duration of life in this species is relatively short, because most of them died within a month's time.

Number of generations.—The following statement is given by Hungerford (10) in regard to this subject: "There is a succession of generations throughout the season, each cycle requiring about twenty-four days". The writer has successfully reared consecutive generations in the laboratory, and the average time spent by 48 reared adults from the abandonment of the egg to maturity was 20 days. This number plus the normal incubation period would coincide with that given above for the length of the life cycle.

Food habits.—Butler (6), in his work on *Mesovelia furcata* Muls. & Rey., speaks of these bugs as being carnivorous in tastes. He gave them freshly killed insects and observed them sucking a Smynthurus, a Crambus, a Chalcid, and a Hydrometra. The same writer was unable to say whether they catch their prey alive or use drowned or partially disabled specimens for food. Hungerford (10) believes that the little bugs are not dependent upon the terrestial insects caught upon the surface film, but spear small Crustacea that are associated with algae and floating *Typha* near the surface of the water. In his isolated rearings, he found it inadvisable to offer spring-tails, as suggested by Butler, for food, and he used plant lice which were not nearly so active and gave better results.

The writer reared *Mesovelia mulsanti bisignata* Uhl. on houseflies and fruit flies, the latter of which, killed with heat, served as excellent food. The rostrum of these insects is very flexible, and while feeding it is bent into whatever position best enables the small bugs to reach the soft parts of their prey. They grasp their prey with the fore-legs and suck the juices.

Behavior.—Uhler (19) in speaking of this species, states that "Nothing could be lighter than their motions over the surface, walking there without making impression or ripple, and moving with the celerity of a spider". *Mesovelia furcata* Muls. & Rey was noted by Butler (6) to assume often a frog-like position, with its head in the air and the body sloping until the hinder extremity almost touches the leaf on which it is standing. This same response, with the hind legs being stretched straight back, occurs in *Mesovelia mulsanti bisignata* Uhl., especially when the surface of the water is disturbed. The adults usually rest on the sides of their containers, completely out of the water but facing it, ready to dart away upon the least disturbance.

These little surface bugs are noted for their cleanly habits, always busily cleaning themselves from hour to hour. The method of "cleaning up" is alike in the three species considered in this paper, and is similar to the following method described by Butler (5) for *Mesovelia furcata* Muls. & Rey: "Each leg on either side rubs its neighbor on that side; the fore pair also clean one another in the manner with which the housefly has made us familiar. With the fore-legs also the insect cleans its antennae and rostrum, drawing the antennae between the two tarsi, and then running the latter down the rostrum, taking great care that the tip of that instrument is thoroughly cleaned. With the second and third pairs of legs they clean the back, by rubbing the tarsi over the surface". They walk about on the water moving the corresponding legs of the opposite sides alternately. Mesovelia hold on to life very tenaciously. Many specimens struggled two or three days to gain on upright position on the water, even after their legs were too weak to support the body, before succumbing.

(to be continued)

BOOK NOTICES

Classification of Insects, A Key to the Known Families of Insects and other Terrestrial Arthropods. By Charles T. Brues and A. L. Melander; 672 pages with 1125 text figures. Bulletin of the Museum of Comparative Zoology, Vol. LXXIII.

The volume contains complete identification keys for the recognition of all the known families of insects and other terrestrial arthropods. Keys are first provided for the determination of the classes of Arthropoda, and others for the determination of the orders of each class. The families are then tabulated under each order. A short list of important genera, with their distribution, is given for each family in the keys, and occasionally the technical and common names of important species are given. The keys distinguish the subfamilies of many of the more extensive families, and keys to the larvae or nymphs are presented for several orders. The pronunciation of each name is indicated, and synonyms correlating the various names applied to families and higher groups are given. Following each key is a selected list of the literature on the classification of the group. The volume concludes with an extensive glossary defining the special terms used in the text and with an adequate index.

Because it considers the world fauna, the larvae of many groups, and the most important literature, the volume escapes the limitations of most works on the subject. The keys themselves are designed for practical use, and on this account, present in part an artificial system. The natural system, however, is presented as well as it can be expressed in a conspectus of families and higher groups. The authors state that in some cases their classification follows recent revision; in others they have presented what seemed to be the most generally acceptable or most rational system. The arrangement of the Hymenoptera and Diptera, and to some extent, of the Coleoptera represents their own viewpoint. The ability of the authors is demonstrated in their consideration of the Coleoptera. In this order they have avoided some recent suggestions which will probably prove to be unsound and also certain others which, while acceptable, cannot be followed satisfactorily in general works until more knowledge is available. The authors have recognized many groups. The insects are divided into thirty-four orders. In the order Coleoptera, twenty-one families are recognized in the Scarabaeoidea and twelve in the Curculionoidea. The volume will prove very useful to all students of the Arthropods.

Common Pests—By R. W. Doane, Professor of Zoology, Stanford University; 384 pp. with 215 text illustrations. Price $4.00 C. C. Thomas, Springfield, Ill.

The object of this handy little volume is to give in a concise way information regarding the more common pests affecting man, his domestic animals, his crops, his storehouse and his home. While dealing in the main with insect pests there are chapters on the near relatives of insects, parasitic worms, mammals and birds.

The book should find a ready sale among farmers, gardeners, householders and others who from time to time suffer from the depredation of pests. It is divided into two sections; section I is entitled "Pests of Man and Domestic Animals" and contains eight chapters on such important topics as blood-sucking flies, mosquitoes, house flies, bedbugs, lice, etc.; section II is on "Insect Control and Important Pests of the Orchard, Garden, Field and Household" and comprises thirteen chapters dealing with the pests of various fruits, truck crops, shade and forest trees, flower garden and greenhouse, storerooms and houses, concluding with a chapter each on mammals and birds as pests. It is profusely illustrated throughout.

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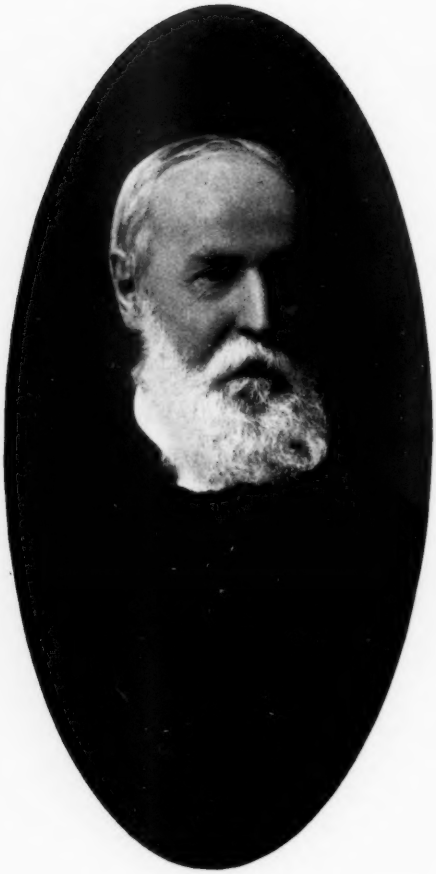

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